Journal of Coastal Development
Volume : 14, Number 1, Ocktober 2010 : 18 - 25

ISSN : 1410-5217
Accredited : 83/Dikti /Kep/2009

Original Paper

STOCK ANALYSIS OF FINE SHRIMP *Metapenaeus elegans* de Man (1907) USING YIELD PER RECRUIT RELATIVE MODEL (Y'/R) AT SEGARA ANAKAN LAGOON CILACAP CENTRAL JAVA

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Received : March, 10, 2010 ; Accepted : August, 5, 2010

ABSTRACT

The research of stock analysis of Metapenaeus elegans was held in Segara Anakan Lagoon, Cilacap Central Java. This research were aimed to study the carapace length of optimal capture, exploitation rate optimum and maximum sustainable yield relative. The research were carried out by using survey method and the sample were collected by systematic random sampling method. Sampling conducted over 11 months, from February until December 2004. Data was analyzed using ELEFAN in FiSAT II software. The result show that rate of exploitation of M. elegans was 0.83 / year, and the length of first capture of the M. elegans was 14.5 mm. At 14.5 mm carapace length, the rate of exploitation (E) should be 0.51 / year, and $E_{0.1}$ was 0.47 / year. The average biomass of exploited for 24% of the initial biomass, which has exceeded the ideal limit of 10% ($E_{0.1}$ concept). According to the above three indicators (the carapace length of shrimp, exploitation rate and biomass used), then the exploitation of M. elegans in Segara Anakan Lagoon has been considered seriously over-exploited. The rate of exploitation has reached 154% of E_{msy} and 177% of $E_{0.1}$. Based on simulation results, the size of carapace length of first capture that produces the MSY is a minimum carapace length of 21.3 mm, and the rate of exploitation (E) can reach 0.7 / year.

Key word *:* Stock;Y'/R, M. Elegans; Segara Anakan Lagoon

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INTODUCTION

Segara Anakan Lagoon is the habitat variety of aquatic and terrestrial organisms, including various species of shrimp. Shrimp species that can be found in Segara Anakan Lagoon, especially from family Penaidae, for example fine shrimp (*Metapenaeus elegans*), *M. ensis, M. affinis, M. dobsoni,* White shrimp (*Penaeus merguiensis*), *P. indicus*, Tiger shrimp (*P. monodon*, *P. semisulcatus*), Krosok shrimp (*Parapenaopsis* sp), from Palaemonidae, and family Hippolytidae. M. *elegans* is a species who has entire life cycle in Segara Anakan Lagoon (Dudley, 2000).

Metapenaeus elegans de Man (1907) is also called fine shrimp (UK), crevette elegance (France), camaron Fino (Spanish) (Chan, 1998), with the local name of "udang jahe", "udang jari" and "dogol biru". Maximum body length of *M. elegans* females and males are 8.4 cm and 11.8 cm, respectively. *M. elegans* are generally caught by traps, push nets, set nets and fishing equipment artisanal (Chan, 1998).

In the Segara Anakan lagoon waters and surrounding, shrimp *M. elegans* caught by "Apong". *M. elegans* is a major catches of the "Apong", besides white shrimp (*P. merguiensis*). Apong highly developed in Segara Anakan Lagoon, because it is very effective for catching shrimp. Apong developed around the early 80s, shortly after trawling banned. In addition to natural factors such as sedimentation and mangrove deforestation, a serious threat to the sustainability of *M. elegans* is exploitation used "Apong", because it has a very small mesh size (0.5 inches), and the number of apong was expected to reach 1660 units (Zarochman, 2001).

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Accredited : 83/Dikti /Kep/2009

The *M. elegans* shrimp stock in the Segara Anakan Lagoon has not been understood and there was no study had been conducted. Estimation of stock using surplus production model that is easier and more simple was constrained by limitation and validity of data on production and trip. Based on such matters, the shrimp stock assessment of *M. elegans* will be conducted using analytical method of yield per recruit model. This research were aimed to study of the carapace length of optimal capture, exploitation rate optimum and maximum sustainable yield relatif (Y'/R).

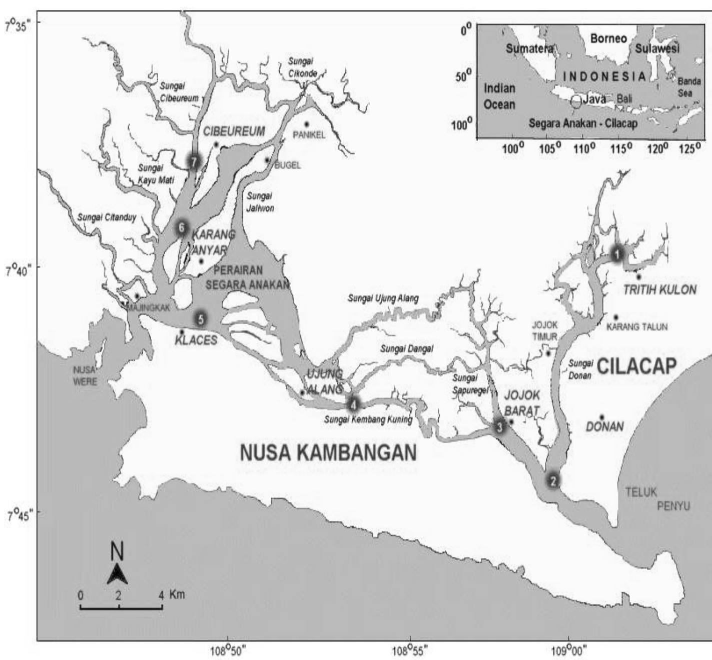
MATERIALS AND METHODS

Materials

Materials and equipment used in the study include: boats, "apong", electric scales (0.01 thoroughness grams), calipers, fine shrimp and preservative (alcohol, formalin and ice).

Research Methods

Research conducted in the waters of Segara Anakan Lagoon, Cilacap District. Sampling conducted over 11 months, from February until December 2004, using survey method, conducted in 7 (seven) observation stations (**Fig. 1**). Sampling carried out at high tide which is the peak fishing season using Apong. At each sampling station prescribed 3 (three) sampling points. *M elegans* was taken at random as much as 10% of the total catch. The shrimp samples were preserved with ice and taken to the laboratory for length and weight measurements.



Description :

● : location of sampling

1 : Tritihkulon ($7^0$39'8" LS; $109^0$01'04" BT)
2 : Muara S. Donan ($7^0$44'31" LS; $108^0$59'42" BT)
3 : Jojok Barat ($7^0$43'5" LS; $108^0$56'27" BT)
4 : Ujungalang ($7^0$13'18" LS; $108^0$50'41" BT)
5 : Klaces ($7^0$39'46" LS; $108^0$49'44" BT)
6 : Karanganyar ($7^0$40'27" LS; $108^0$49'16" BT)
7 : Cibeureum ($7^0$39'21" LS; $108^0$48'19" BT)

Fig1. Map of Segara Anakan area and location of sampling

Data Analysis

Stock analysis model Y' / R needs input variables: L_∞ (infinite length), K (index of the growth curve of von Bertalanffy), Z (total mortality rate), F (fishing mortality rate), E (rate of exploitation), L_c (length of first capture) and t_o (theoretical age at length of time the shrimp). These variables were analyzed using the tools FiSAT II program.

Determination of Y/R was calculated using Beverton and Holt method (1966) which is a revision to change the parameters of the previous model.

Equation Y/R Y/R that prior to the reparameters are:

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$$\frac{Y}{R} = F.W\infty.\frac{1}{Z} + \frac{3S}{Z+K} + \frac{3S^2}{Z+2K} + \frac{S^3}{z+3K}$$

Description:
$S = e^{-K(tc-to)}$
K = index of the growth curve of von Bertalanffy
t_o = theoretical age at length of time the shrimp = 0
t_c = age of the first capture
t_r = age at the time of entry shrimp fishery (recruiting)
F = fishing mortality rate
M = natural mortality rate
Z = total mortality rate = F + M

From the above model, the parameters that can be controlled is F and tc, while the other parameters are natural. Therefore the model Y / R is considered as a function of F and t_c. Beverton (1963) developed the model by doing reparameterisation so that Y/R has no unit and the equation was as follow:

$$Y = \frac{Y}{RW\infty} = E\sum_{n=0}^{3}\frac{Un.(1-c)n}{nK/1+(M)(1-E)}$$

description:
ال = yield per recruit, no units.
E = rate of exploitation
M = natural mortality rate
c = ratio of length of first capture and length of infinity (L_c-L_∞)
K, L_∞ and to the von Bertalanffy growth parameters
Y = catch
R = abundance of age groups L_c
Un = is the coefficient sumasi, taken the value 1, -3, 3, -1 for n = 0, 1, 2, 3.
To assess the influence of changes in L_c t_o the Y / R, re-parameters made by Beverton and Holt (1966) as follows:

$$Y' = \left(\frac{Y'}{R}\right) = \frac{Y}{N_{(to)}W_\infty} = (1-c)^{\frac{M}{K}}Y$$

Description:
N (to) = number of existing cohorts at the age t_o
To simplify the calculation, the equation can be written as:

$$(Y/R)' = E * U^{M/K} * \left(1 - \frac{3U}{1+m}\right) + \frac{3U^2}{1+2m} + \frac{3U^3}{1+3m}$$

Description : m = K/Z
U = $1 - L_c/L_\infty$
E = F/Z

The relative yield (Y ') is a function of exploitation rate (E), U (1 - L_c / L_∞) and M / K. The first two parameters, namely E (F / Z) and c (L_c / L_∞) can be controlled, while the M / K only biological parameters are needed in the analysis. This model can be used to determine the optimum combination of number of fishing efforts (measured with a fishing mortality rate, F), and age or length of first capture (L_c), which will produce the maximum sustainable yield, while biomass per recruit obtained by the equation: B' / R = Y' / R * 1 / F.
MSY optimum value obtained using the simulation by inserting variation L_c value (carapace length of first capture) and E (exploitation rate).

Results And Discussion

The number of young *M. elegans* entering to Segara Anakan Lagoon (number of recruits) has not been known yet. Production and the number of fishing trip data were hardly obtained and no valid data were observed, because the production and fishing trip did not recorded in the Fish Landing Area. Therefore, estimates the number of recruiting used yield relative, *ie* the Relative Yield per Recruit, (Y '/ R) model of Beverton and Holt (1966). Stock analysis model Y' / R needs input variables: L_∞ (infinite length), K (index von Bertalanffy growth curve), Z (total mortality rate), F (fishing mortality rate), E (exploitation rate), L_c (length of the first capture) and t_o (theoretical age at zero length of shrimp). These variables have been done earlier calculations and the results are presented in **Table 1.** These variables in **Table 1,** which can be controlled by the management is F (fishing mortality rate) and L_c (the length of first capture). Management effort was done by adjusting the number of fishing effort and mesh size. Determining the amount of fishing effort will has implications to the size of natural mortality (M), while determining mesh size and / or fishing season will has implications to the size of L_c.

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Table 1. Variables needed in the calculation of Y/R relative

Parameter	Value
L_∞ (mm)	42,620
K (per year)	1,300
Z (per year)	8,190
M (per year)	1,430
F (per year)	6,760
E (per year)	0,830
L_c (mm)	14,500
t_o (year)	-0,017

Based on the calculation of Y '/ R using the variables listed in **Table 1,** the results are presented in **Fig. 2.**

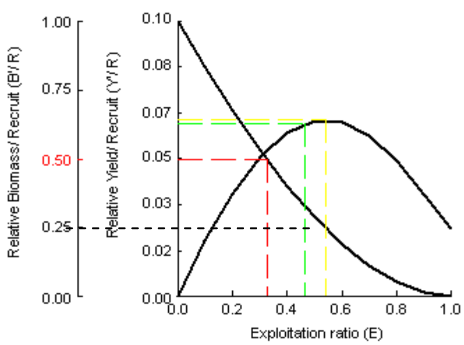

Fig. 2. The relationship between the rate of exploitation with Y'/R and B'/R (L_c = 14.5 mm).

At L_c of 14.5 mm, the maximum exploitation rate (E_{max} = rate of exploitation that generates Y' / R maximum) was 0.54 / year. The amount of Y' / R maximum or Relative MSY for 0.067. Biomass per recruit at the E_{max} was 0.24 or 24% of virgin biomass (initial biomass). That is, if the carapace length of first capature with size of 14.5 mm, to produce MSY relative, will spend 24% of initial biomass in the waters.

If L_c was enlarged at 23.3 mm (**Fig. 3**), namely the size of the growing speed change, the Relative MSY increased by 18% to 0.079 and E_{max} increased to 0.73/year, whereas the average biomass per recruit relative decreased to 14% of the B_v.

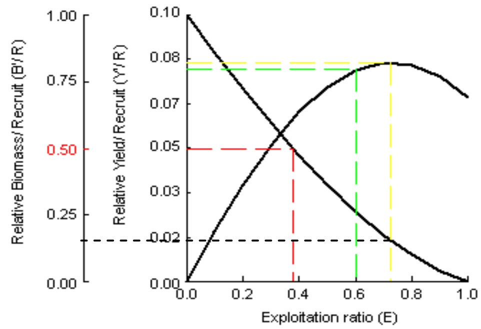

Fig. 3. The relationship between the rate of exploitation with Y'/R and B'/R (Lc = 23.3 mm).

If the L_c was 25.5 mm (**Fig. 4**), the Relative MSY will be increased by 6% to 0.083 by E_{max} of 0.79 / year and B' / R relative to 12% of the Bv. This shows that the larger shrimp caught will lead to increase production. On the other hand, the number of fishing trips or the rate of exploitation that can be tolerated will be even greater, reaching 0.79 / year, and biomass of shrimp in the waters that exploited the smaller, that is only 12% of initial biomass. In this condition, the sustainability of shrimp resources and fishing business continuity is assured.

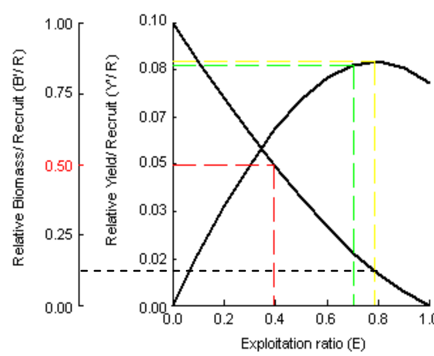

Fig. 4. The relationship between the rate of exploitation with Y'/R and B'/R (L_c = 25.5 mm).

Conversely, if L_c reduce to 12.5 mm (**Fig. 5**), the relative MSY will drop by 9% compared to L_c = 14.5 mm, which was only 0061, with E_{MSY} was 0.51/year and B'/ R for 25% of B_v. On the size, the shrimp caught were too small, and can lead to overfishing. This will result in delay in the recruitment and growth of new stock in the waters. At the same time, the exploited biomass is very large (25% of the

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Accredited : 83/Dikti /Kep/2009

initial bioamss), so the stock in the wild would quickly run out. Based on the concept of responsible fisheries, the ideal size of exploited stocks is 10% of the initial stock.

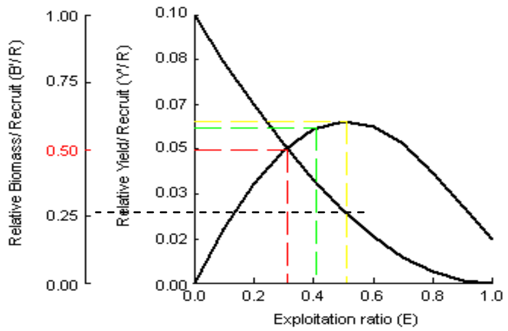

Fig. 5 The relationship between the rate of exploitation with Y'/R and B'/R (L_c = 12.5 mm).

Most of the experts who prefer cautious in determining the quota of production, suggesting the rate of exploitation at the level of $F_{0.1}$. Analogous to the concept of $F_{0.1}$ by Widodo (1988) is F = M (E / (1-E) equals $E_{0.1}$. The concept of responsible fisheries (code of conduct responsible fisheries) also recommended the use of such $E_{0.1}$. $E_{0.1}$ is the rate of exploitation that refer to biomass exploitation for only 10% of the initial biomass. $E_{0.1}$ theoretical point can be obtained when the curve Y' / R as a function of E has a slope angle with of 0.1. In this study, the $E_{0.1}$ amount that provides for MSY is 0.47/ year if the lengt of first capture was 14.5 mm, or about 0.6 / year if the size of the average caught was 23.3 mm.

$E_{0.1}$ concept is firstly applied to fisheries in the North Atlantic in the early 70's, and since then widely used in the management of fisheries resources in various areas (Widodo 1988). As the rate of exploitation has now reached 0.83/ year, which means it exceeds the maximum exploitation rate (E_{MSY}) and the rate of exploitation $E_{0.1}$. When compared with the maximum exploitation rate (E_{MSY}), means the exploitation of *M. elegans* now has reached 154% or excess fishing effort by 54%. However, compared with $E_{0.1}$ the exploitation level of *M. elegans* now has reached 177% or excess fishing effort by 77%. Over exploitation occured due go to growth overfishing, because the length of carapace *M. elegans* caught too small (only 14.5 mm).

Simulation Y' / R to change the rate of exploitation (E) at three levels of M / K and various values of c (L_c / L_∞) is presented in **Fig. 6.** The variables that determine the amount of Y' / R or relative MSY is the size of L_c, E and M / K. The first two parameters, namely c and E can be managed, while M and K is a parameter out of range management. L_c value is a function of the mesh size, because L_c = MS/SF. MS is mesh size and SF is selectivity factor.

Value of E is a function of the number of fishing effort, because, F = qf, and f is the number of fishing effort, so that E = (qf) / Z. Change the value L_c will result in changes to the value of Y / R 'and B / R', as well as changes in the value of E.

Simulation results performed that the current conditions, (M / K = 1.1, **Fig. 6a**), shows that the relative MSY obtained with L_c = 29.8 mm, E = 0.9/year. At E = 0.5 per year, relative MSY for 0.074, which achieved if L_c = 23.4 mm. If the rate of exploitation (E) is E = 0.7, then the relative MSY be 0.086, occurred at L_c = 25.5 mm. This shows that if the size of shrimp caught enlarged, which result in increase of exploitation capacity.

If the rate of natural mortality (M) is reduced, such as improving the environment and habitat, so that the ratio M / K becomes smaller, eg = 0.6, relative MSY obtained at L_c = 34 mm, with E_{MSY} for 0.9/ year (**Fig. 6a**). At E = 0.7 per year, relative MSY for 0.16, which is achieved if L_c = 29.8 mm. If the rate of exploitation (E) reduced (E = 0.5), will be followed by a decrease in the relative MSY, became 0.15, and occurs in L_c = 25.5 mm.

Journal of Coastal Development ISSN : 1410-5217
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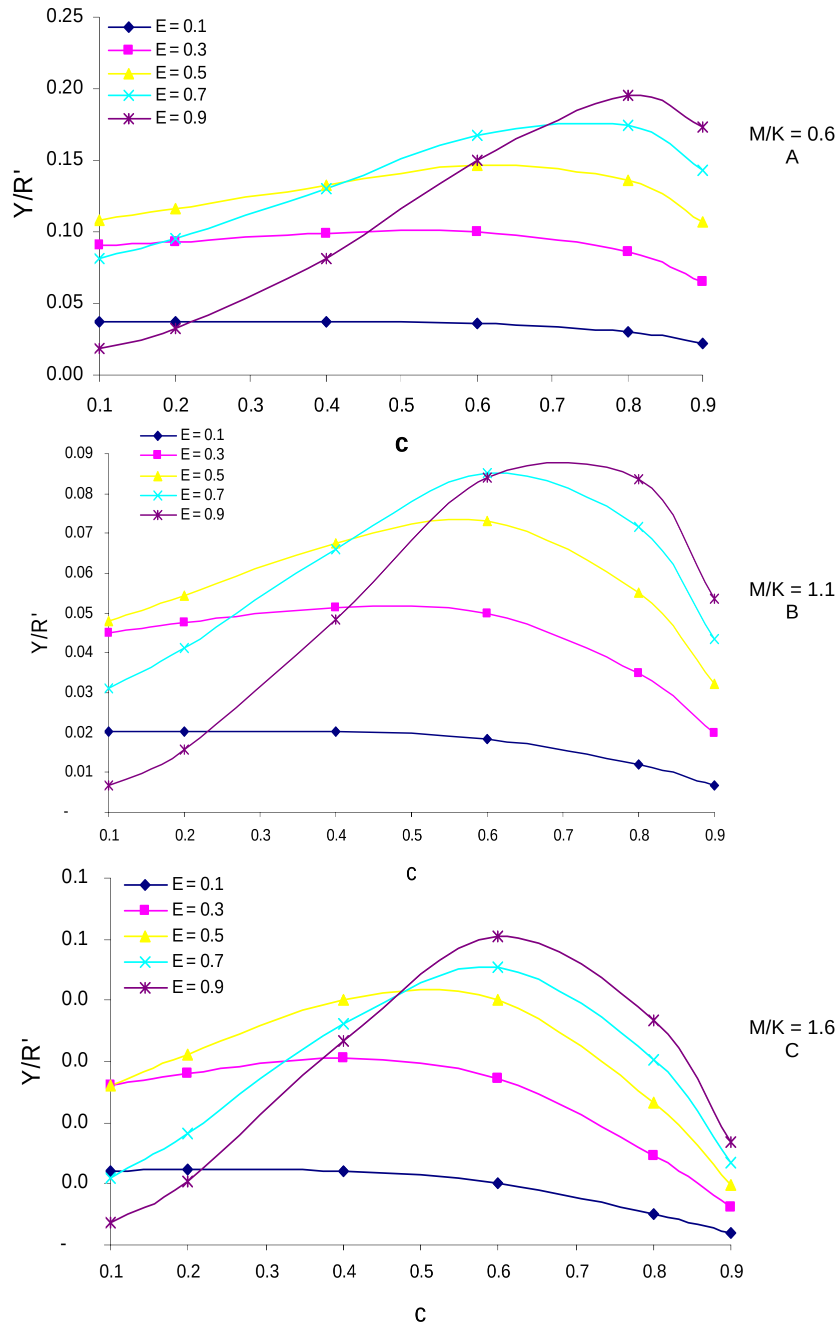

Fig. 6. The relationship between the value of c (L_c/L_∞) with Y'/R, at various levels of exploitation (E) and three levels of M / K.

Sparre *et.al.*, (1989) mentions the maximum point of the curve Y' / R as MSY (maximum sustainable yield), depends on t_c (age of first captured) or L_c (if use long database). L_c depends on the mesh size of nets used.

Based on the simulation of Y' / R to change the value of E above, the optimum relative MSY occurs at L_c = 21.3 mm, with the rate of exploitation 0.7/ year. When compared to the size of shrimp caught in the present (carapace length 14.5 mm and weighs 1.4

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Accredited : 83/Dikti /Kep/2009

grams per individual), there will be increasing production by 179% (weight at L_c = 21.3 mm is 3.9 gr).

The results of the analysis of the interaction between L_c / L_∞ with the rate of exploitation (E) as gives Y' / R, presented in **Fig.7**. shows the response of the outcome of a Y'/R to changes in L_c / L_∞ and E in a range of both parameters, the best E value of L_c / L_∞ particular.

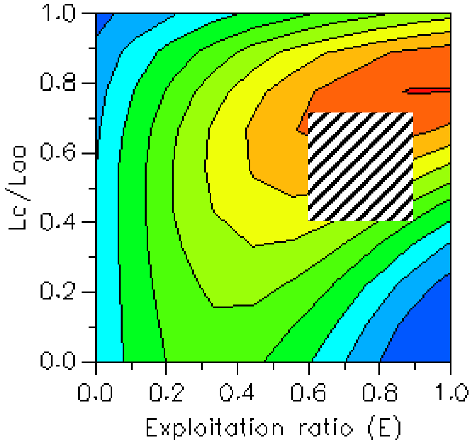

Fig. 7. The relationship Y' / R with c (L_c / L_∞) and the exploitation ratio (E) of *M. elegans* in the Segara Anakan Lagoon.

In the cases of *M. elegans*, L_c / L_∞ ranged from 0.34 to 0.38, at the optimum exploitation rate ranged from 0.47/ year to 0.54/ year, has not produced the optimum relative MSY. Relative MSY is optimum in the range L_c / L_∞ between 0.5 (L_c = 21.3 mm) and 0.7 (L_c = 29.8 mm), with a maximum exploitation rate (E_{max}) ranged from 0.7/year to 0.9/year (hatching area).

Based on the prediction Beverton and Holt model, simulation Y' / R to change L_c, the value of Y' / R optimum (relative MSY) was achieved if the carapace length of first capture (L_c) of at least 21.3 mm and the rate of exploitation (E) for 0.7/ year. Its means that if we requires increase in yield, the average size of shrimp caught must be raised. In current conditions, where E = 0.83/year, L_c should be 27.7 mm. At such carapace length, number of mature female shrimp will be more available. If L_c *M. elegans* is 27.7 mm, while the value of selection factor of Apong is 0.56, consequently the mesh size of Apong is 50 mm or 5 centimeters or 2 inches.

Research conducted by Amin, *et.al.*, (2009) against *Acetes japonicus* shrimp using Y / R relative to conclude that the maximum exploited rate (E_{max}) = 0.52, and the stock was found to be over exploited in the investigated area. This value is smaller dibanidng exploitation rate of shrimp in ly Metapeaneus elegans which had reached 0.54. Using the method of relative yield per recruit for the group elasmobranchii fish in the Java Sea, Blaber *et al.*, (2009) obtained the result indicate strongly that many of the shark and ray species in Indonesia are overfished, according to the results of research using other methods. Allam (2003) reported the research using Y / R model of Boops Boops fish at Meditteranian water that the current fishery harvests approximately 95% of the potential yield.

Many studies show that the results of research using the model Y / R is very good as a basis for the preparation of the concept of fisheries management. The result of Yield per recruit and related analyses were used to integrate biological information to indicate the productivity of each species to allow for management policy options and constraints (Blaber, *et al.*, 2009, Peixer *et al.*, 2007).

CONCLUSION

Based on the above description be concluded that:

1. The rate of exploitation of shrimp *M. elegans* was 0.83 / year, and the length of first capture of the *M. elegans* was 14.5 mm.
2. The rate of exploitation (E) with a carapace length of first captured 14.5 was in fact it should be 0.51 mm / year, and $E_{0.1}$ of 0.47 / year.
3. The average biomass exploited was 24% of the initial biomass, which has exceeded the ideal limit of 10% ($E_{0.1}$ concept).
4. Based on the above three indicators (the carapace length of shrimp, exploitation rate and biomass used), the exploitation of *M. elegans* in Segara Anakan Lagoon has been seriously over-exploited. The rate of exploitation has reached 154% over E_{msy} and 177% over $E_{0.1}$.

5. Based on simulation results, the size of carapace length of first capture that produces the MSY is a minimum carapace length of 21.3 mm, and the rate of exploitation (E) can reach 0.7 / year.

REFERENCES

Allam, S. M., 2003. Growth, Mortality And Yield Per Recruit of Bogue, Boops Boops (L.), From The Egyptian Mediterranean Waters Off Alexandria. *Medit. Mar. Sci*., 4(1) : 87-96.

Amin, S.M.N., A. Arsyad; S.S. Siraj and B. Japar Sidik. 2009. Population structure, growth, mortality and yield per rucruit of segestid shrimp, *Acetes japonicus* (Decapoda: Sergestidae) from the coastal waters of Malacca. Peninsular Malaysia.Indian *J. Mar.Scie*.(38)1: 57-68.

Blaber, S. J. M., C. M. Dichmont, Æ. W. White, R. Buckworth, L. Sadiyah Æ. B. Iskandar, S. Nurhakim, R. Pillans; R. Andamari, Dharmadi and Fahmi. 2009. Elasmobranchs in Southern Indonesian fisheries: the fisheries, the status of the stocks and management options. *Rev Fish Biol Fish*, 19:367-391.

Beverton R.H.J., 1963. Maturation, growth and mortality of clupeid and engraulid stocks in relation to fishing. Rapp.P.V.Reun.CIEM.154:44-67.

Beverton R.J.H., and S.J. Holt. 1966. Manual of methods for fish stock assessment. part II. Tables of yield function. FAO Fish. Tech. Pap. (38)(Rev-1) 67p.

Chan, TY., 1998. Shrimps and prawns. In: Carpenter, KE and VH. Niem. 1998. The Living Marine Resources of the Western Central Pasific. Vol. 2. Cephalopods, Crustaceans, Holothurians and Sharks. Food and Agriculture Organization of the United Nations Rome.

Merta I.G.S., and S. Nurhakim. 2001. Analytical models. In: Djamali A, OK Sumadhiharga, B Sumiono and Sulistijo (Eds). Stock Assessment guiding Fish Aquatic Resources Indonesia. Project Research and Exploitation of Marine Resources. Fishing Research Center. Board of Marine and Fisheries Research - DKP and Research Center for Oceanography - LIPI. Jakarta.

Peixer J.., A.C. Catella and M. Petrere Júnior. 2007. Yield per recruit of the pacu Piaractus mesopotamicus (Holmberg, 1887) in the pantanal of Mato Grosso do Sul, Brazil. *Braz J Biol*. 67(3):561-7.

Sparre, P., E. Ursin and Venema. 1989. Introduction to tropical fish stock assessment Part I -Manual. Food and Agriculture Organisation. Fisheries Technical Paper. FAO of the United Nations, Rome : 337 p.

Widodo, J.1991. Maturity and spawning of shortfin Scad (*Decapterus macrosoma*) (Carangidae) of the Java Sea. *Asian Fish Scie*, 4, 245-252.

Widodo, J. 1988. Population parameters of Scad mackerel (*Decapterus* spp.) (Pisces: Carangidae) in the Java Sea. Journal Pen. No Sea Fisheries. 46 Th.1988 p.11-44.

Zarochman. 2001. Laju tangkap udang dan masalah jaring apong di Plawangan Timur Laguna Segara Anakan. [MS Thesis]. Program Pascasarjana Universitas Diponegoro Semarang.